

WHAT IS CLAIMED IS:

1 1. A porous substrate for epitaxial growth, comprising:
2 an underlying layer made of III-nitride semiconductor;
3 a void-formation preventive layer grown on the underlying
4 layer;
5 a porous III-nitride semiconductor layer; and
6 a porous metallic layer grown on the porous III-nitride
7 semiconductor layer.

1 2. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:
3 the underlying layer made of III-nitride semiconductor
4 is a GaN free-standing substrate.

1 3. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:
3 the underlying layer made of III-nitride semiconductor
4 is grown on a base material.

1 4. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:
3 a thickness of the underlying layer made of III-nitride
4 semiconductor is 300 nm or more.

1 5. The porous substrate for epitaxial growth as defined
2 in claim 3, wherein:

3 the base material is prepared from at least one material
4 selected from the group consisting of sapphire, silicon,
5 silicon carbide, langasite, zirconium diboride, and gallium
6 arsenide.

1 6. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:

3 the III-nitride semiconductor is prepared from at least
4 one material selected from the group consisting of GaN, AlGaN,
5 InGaN, and InAlGaN.

1 7. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:

3 the void-formation preventive layer has less than 6%
4 lattice constant difference with respect to that of the
5 underlying layer.

1 8. The porous substrate for epitaxial growth as defined
2 in claim 7, wherein:

3 the void-formation preventive layer is prepared from
4 AlGaN.

1 9. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:

3 the void-formation preventive layer is a superlattice
4 structure composed of alternately grown plural pairs of an
5 $\text{Al}_x\text{Ga}_{1-x}\text{N}$ ($0 < x \leq 0.5$) layer and an $\text{Al}_y\text{Ga}_{1-y}\text{N}$ ($0 \leq y < x$) layer.

1 10. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:

3 a thickness of the void-formation preventive layer is 3
4 nm or more.

1 11. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:

3 a thickness of the porous III-nitride semiconductor layer
4 is 3 μm or less.

1 12. The porous substrate for epitaxial growth as defined
2 in claim 1, wherein:

3 the porous metallic layer is prepared from at least one
4 material selected from the group consisting of titanium,
5 vanadium, chromium, manganese, iron, cobalt, nickel, copper,
6 yttrium, zirconium, niobium, molybdenum, tellurium, ruthenium,
7 rhodium, palladium, hafnium, tantalum, tungsten, rhenium,
8 osmium, iridium, platinum, and gold, or the nitrides thereof.

1 13. A porous substrate for epitaxial growth, comprising:

2 a sapphire substrate;

3 a GaN layer grown on the sapphire substrate;

4 an AlGa_N layer grown on the Ga_N layer;
5 a porous Ga_N layer grown on the AlGa_N layer; and
6 a porous TiN layer.

1 14. A method for manufacturing a porous substrate for
2 epitaxial growth, comprising the steps of:
3 growing a void-formation preventive layer on an
4 underlying layer made of III-nitride semiconductor;
5 growing III-nitride semiconductor layer on the
6 void-formation preventive layer;
7 growing a metallic layer on the III-nitride semiconductor
8 layer; and
9 forming voids in the III-nitride semiconductor layer and
10 the metallic layer grown on the void-formation preventive
11 layer.

1 15. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 14, wherein:
3 the underlying layer prepared from the III-nitride
4 semiconductor is a Ga_N free-standing substrate.

1 16. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 14, further comprising the
3 step of:
4 growing the underlying layer made of the III-nitride
5 semiconductor on a base material.

1 17. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 16, wherein:

3 the base material is prepared from at least one material
4 selected from the group consisting of sapphire, silicon,
5 silicon carbide, langasite, zirconium diboride, and gallium
6 arsenide.

1 18. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 14, wherein:

3 the III-nitride semiconductor is prepared from at least
4 one material selected from the group consisting of GaN, AlGaN,
5 InGaN, and InAlGaN.

1 19. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 14, wherein:

3 the void-formation preventive layer is made of AlGaN or
4 a metallic nitride having a lattice constant close to that of
5 the underlying layer.

1 20. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 14, wherein:

3 the void-formation preventive layer is a superlattice
4 structure composed of alternately grown plural pairs of an
5 $\text{Al}_x\text{Ga}_{1-x}\text{N}$ ($0 < x \leq 0.5$) layer and an $\text{Al}_y\text{Ga}_{1-y}\text{N}$ ($0 \leq y < x$) layer.

1 21. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 14, wherein:

3 the metallic porous layer is made of at least one material
4 selected from the group consisting of titanium, vanadium,
5 chromium, manganese, iron, cobalt, nickel, copper, yttrium,
6 zirconium, niobium, molybdenum, tellurium, ruthenium, rhodium,
7 palladium, hafnium, tantalum, tungsten, rhenium, osmium,
8 iridium, platinum, and gold, or the nitrides thereof.

1 22. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 14, further comprising the
3 step of:

4 forming voids in the III-nitride semiconductor layer and
5 the metallic layer grown on the void-formation preventive layer
6 by means of the heat treatment.

1 23. The method for manufacturing a porous substrate for
2 epitaxial growth as defined in claim 22, wherein:

3 the heat treatment is implemented in an atmosphere
4 containing hydrogen gas or a hydride gas.

1 24. A method for manufacturing a porous substrate for
2 epitaxial growth, comprising the steps of:

3 growing a first GaN layer on a sapphire substrate;
4 growing an AlGaN layer on the first GaN layer;
5 growing a second GaN layer on the AlGaN layer;

6 growing a Ti layer on the second GaN layer; and
7 heat-treating the second GaN layer and the Ti layer in
8 a mixed gas atmosphere of hydrogen gas and a hydride gas to
9 form voids in the second GaN layer and the Ti layer.

1 25. A method for manufacturing III-nitride
2 semiconductor substrate, comprising the steps of:
3 growing a void-formation preventive layer on an
4 underlying layer made of III-nitride semiconductor;
5 growing III-nitride semiconductor layer on the
6 void-formation preventive layer;
7 growing a metallic layer on the III-nitride semiconductor
8 layer;
9 forming voids in the III-nitride semiconductor layer and
10 the metallic layer grown on the void-formation preventive
11 layer;
12 epitaxially growing III-nitride semiconductor substrate
13 on the metallic layer in which voids are formed; and
14 exfoliating the III-nitride semiconductor substrate from
15 the metallic layer.

1 26. The method for manufacturing III-nitride
2 semiconductor substrate as defined in claim 25, wherein:
3 the underlying layer made of the III-nitride
4 semiconductor is a GaN free-standing substrate.

1 27. The method for manufacturing III-nitride
2 semiconductor substrate as defined in claim 25, further
3 comprising the step of:
4 growing the underlying layer made of the III-nitride
5 semiconductor on a base material.

1 28. The method for manufacturing III-nitride
2 semiconductor substrate as defined in claim 27, wherein:
3 the base material is prepared from at least one material
4 selected from the group consisting of sapphire, silicon,
5 silicon carbide, langasite, zirconium diboride, and gallium
6 arsenide.

1 29. The method for manufacturing III-nitride
2 semiconductor substrate as defined in claim 25, wherein:
3 the III-nitride semiconductor is prepared from at least
4 one material selected from the group consisting of GaN, AlGaN,
5 InGaN, and InAlGaN.

1 30. The method for manufacturing III-nitride
2 semiconductor substrate as defined in claim 25, wherein:
3 the void-formation preventive layer is made of AlGaN or
4 a metallic nitride having a lattice constant close to that of
5 the underlying layer.

1 31. The method for manufacturing III-nitride

2 semiconductor substrate as defined in claim 25, wherein:
3 the void-formation preventive layer is a superlattice
4 structure composed of alternately grown plural pairs of an
5 $\text{Al}_x\text{Ga}_{1-x}\text{N}$ ($0 < x \leq 0.5$) layer and an $\text{Al}_y\text{Ga}_{1-y}\text{N}$ ($0 \leq y < x$) layer.

1 32. The method for manufacturing III-nitride
2 semiconductor substrate as defined in claim 25, wherein:
3 the metallic porous layer is made of at least one material
4 selected from the group consisting of titanium, vanadium,
5 chromium, manganese, iron, cobalt, nickel, copper, yttrium,
6 zirconium, niobium, molybdenum, tellurium, ruthenium, rhodium,
7 palladium, hafnium, tantalum, tungsten, rhenium, osmium,
8 iridium, platinum, and gold, or the nitrides thereof.

1 33. The method for manufacturing III-nitride
2 semiconductor substrate as defined in claim 25, further
3 comprising the step of:
4 forming voids in the III-nitride semiconductor layer and
5 the metallic layer grown on the void-formation preventive layer
6 by means of the heat treatment.

1 34. The method for manufacturing III-nitride
2 semiconductor substrate as defined in claim 33, wherein:
3 the heat treatment is implemented in an atmosphere
4 containing hydrogen gas or a hydride gas.

1 35. A method for manufacturing III-nitride
2 semiconductor substrate, comprising the steps of:
3 growing a first GaN layer on a sapphire substrate;
4 growing an AlGaN layer on the first GaN layer;
5 growing a second GaN layer on the AlGaN layer;
6 growing a Ti layer on the second GaN layer; and
7 heat-treating the second GaN layer and the Ti layer in
8 a mixed gas atmosphere of hydrogen gas and a hydride gas to
9 form voids in the second GaN layer and the Ti layer;
10 epitaxially growing a GaN substrate on the Ti layer in
11 which voids are formed; and
12 exfoliating the GaN substrate from the Ti layer.